# Key Elements in Fielding Capabilities

John D. Holcomb and Michael Hoehn
*76th Software Maintenance Group*

*Organizations that develop software for the Department of Defense must have knowledgeable people to do the work according to documented and mature processes and standards that guide how the work is accomplished. The organization must also have in place the hardware and tools that are used to execute the processes to develop and test the end products. Success of their efforts depends on two key elements: the fidelity of the test environment, and the amount of collaboration with other agencies involved in their program.*

The mission of the 76th Software Maintenance Group (SMXG, formerly MAS) at the Oklahoma City-Air Logistics Center, Tinker Air Force Base (AFB), Okla., includes positioning operational capabilities in the field, and improving and adding to them through software development and sustainment. The 76th SMXG performs this mission for the E-3, B-1, B-2, and B-52 aircraft, and for the Air Launched Cruise Missile (ALCM), Conventional Air Launched Cruise Missile (CALCM), and Advanced Cruise Missile (ACM) weapons. The group also has extensive capability for development and maintenance of Test Program Set hardware and software for automatic test equipment; industrial automation; and jet engine testing, trending, and diagnostics.

Any organization that develops or maintains weapon system software must have certain resources in place. These resources include people, a development environment, a test environment, tools, and facilities to house these resources. Policies, instructions, standards, and processes are required to control how the work is accomplished. Measurement and metrics requirements must be established to facilitate tracking workload/labor; to evaluate financial and project performance; and to establish the foundations for pricing future projects, making management decisions, and process improvement efforts. We have an outstanding Software Engineering Process Group (SEPG) that organizes and develops processes and standards, and maintains them online. It also establishes and manages our measurement and metrics requirements and process improvement efforts and the organizational software quality program.

The 76th SMXG consists of approximately 500 engineers, computer scientists, and staff personnel, the majority of whom have in excess of 15 years experience in the organization. Various development environments are used based on the weapon system or automatic test equipment that the application software runs on, however, most applications are developed on IBM mainframes, Sun workstations, or networked personal computers. Tools used include assemblers, compilers, and tools for project planning and management, labor tracking, requirements tracking, configuration management, documentation, etc. A detailed discussion of all aspects of our operation is not possible within the scope of this article, and most readers are aware of these aspects from their own experience. Thus this article will focus on two key areas that reduce risk when fielding operational capabilities: high fidelity test environments and collaboration.

## High Fidelity Test Environments

The test environment is one of the key elements in fielding capabilities. If it does not emulate the fielded system to the maximum extent possible, then the risk of operational problems when the software is fielded increases. The initial Avionics Integrated Support Facility Military Construction Project at Tinker AFB was built in the early 1980s to provide floor space to house the software support personnel and development environments for the E-3, B-52, Short Range Attack Missile (SRAM), and the ALCM. An example of our high fidelity test environments, the B-52 Avionics Integrated Support Facility (AISF), is a hot mockup of the aircraft avionics interfaced with the controls and displays. Simulated dynamics of the aircraft are provided by a vehicle system simulator, and weapon simulation is provided by a weapon system simulator.

The SRAM and ALCM laboratory area was built adjacent to the B-52 AISF area. The cruise missile project provided interfaces between the B-52 AISF and empty/loaded pylon/launcher station as well as between the AISF and the ALCM subsystem simulator. This test environment is used for simulation and test of the B-52 operational flight software, the aircraft to missiles interfaces, and the missile operational flight software. By utilizing the combination of the B-52 AISF and pylon or launcher loaded with test missiles, all communication between the aircraft and missiles can be effectively tested. The SRAM program has been disposed of and the missiles laboratory has evolved through the years to include capability for ACM and CALCM.

A missile electronic subsystem simulator, consisting of a table of interfaced missile electronics, is also available. Breakout boxes can be used at the umbilical connector, or at any of the internal missile interface connectors to allow monitoring of the interfaces. Testing of the B-52 operational flight software and missile operational flight program is accomplished by first planning the mission, then flying the aircraft mission on the AISF, rotating the launcher to the proper missile, if necessary, then simulating launch, and finally simulating free flight of the missile to target.

The AISF interface with the ALCM subsystem simulator is used to test aircraft/missile interface up to launch and subsequently test free-flight simulation of the missile operational flight program from launch to detonation at target. Successful testing of B-52 and missile operational flight software and mission planning software in this laboratory provides very high confidence that flight testing will be successful and that the software will provide the required capability when fielded.

A government owned and operated test environment for weapon systems has benefits other than the ability to fully test the software. Having this capability in a government facility allows it to be used for competitive procurement of projects that are beyond organic capability. For example, a B-52 modification was programmed and funded, but the sole-source contractor's price for developing the modification at the company's facility was in excess of the budget. We recommended to the program office that the project be competitively procured based on performance in our government facility. The effort was competed, development and

# Report Documentation Page

*Form Approved*
*OMB No. 0704-0188*



| 1. REPORT DATE | 2. REPORT TYPE | 3. DATES COVERED |
|---|---|---|
| **AUG 2005** | | **00-00-2005 to 00-00-2005** |

| 4. TITLE AND SUBTITLE | 5a. CONTRACT NUMBER |
|---|---|
| **Key Elements in Fielding Capabilities** | 5b. GRANT NUMBER |
| | 5c. PROGRAM ELEMENT NUMBER |
| 6. AUTHOR(S) | 5d. PROJECT NUMBER |
| | 5e. TASK NUMBER |
| | 5f. WORK UNIT NUMBER |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **76th Software Maintenance Group,4750 Staff Dr,Tinker AFB,OK,73145-3318** | 8. PERFORMING ORGANIZATION REPORT NUMBER |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) | 10. SPONSOR/MONITOR'S ACRONYM(S) |
| | 11. SPONSOR/MONITOR'S REPORT NUMBER(S) |

12. DISTRIBUTION/AVAILABILITY STATEMENT
**Approved for public release; distribution unlimited**

13. SUPPLEMENTARY NOTES
**CROSSTALK The Journal of Defense Software Engineering, August 2005**

14. ABSTRACT

15. SUBJECT TERMS

| 16. SECURITY CLASSIFICATION OF: | | | 17. LIMITATION OF ABSTRACT | 18. NUMBER OF PAGES | 19a. NAME OF RESPONSIBLE PERSON |
|---|---|---|---|---|---|
| a. REPORT **unclassified** | b. ABSTRACT **unclassified** | c. THIS PAGE **unclassified** | **Same as Report (SAR)** | **4** | |

testing was accomplished in the AISF by the winning contractor, and the final cost was approximately one half of the original bid.

Another additional benefit is the expertise that organic personnel develop as a result of having this type of laboratory. An example of this occurred after two B-52/ALCM-W80-1 Joint Test Assembly (JTA) flight tests resulted in aborted launches with total mission failure. An analysis of the mission data indicated a problem between the B-52 offensive avionics system (OAS) and the missile test payload (W80-1 JTA). After returning to the home base, the aircraft underwent extensive ground testing by Air Force personnel and no problem could be found. Sandia National Laboratories performed a series of comprehensive tests on their JTA package and concluded that it did not contribute to the aborted launches. Sandia further prepared a letter to the Cruise Missile Product Division detailing their findings and recommending the Air Force suspend future B-52/ALCM JTA flight tests until the Air Force could identify the source and correct the problem.

This problem was referred to our engineers, and the B-52/missiles laboratories were configured for an ALCM JTA launch using missile and B-52 production hardware and operational software. Utilizing state-of-the-art recording and analysis tools, engineers performed multiple JTA launches. Analysis of the laboratory flight test data and the JTA data from the aborted launches clearly determined that the aborted launches were a result of the JTA package. Having determined the source of the problem, engineers from the AISF presented their findings identifying the JTA as the source of the problem and isolating specific circuits in the JTA that were suspect. Sandia accepted these findings, had additional testing performed on the suspected circuits, and was able to isolate the specific failure mode.

Similar test environment capabilities exist in all of our weapon system laboratories. For example, the E-3 Airborne Warning and Control System (AWACS) laboratory has both surveillance radar configurations; this way, all versions of the E-3 software can be tested. During Desert Shield/Desert Storm, an enhancement was required to support that effort. The requirement was identified on Thursday. The change was programmed, implemented, tested in the laboratory, flight tested at Tinker AFB, and sent to the theatre on a resupply flight the next Monday. This demonstrated the fast turnaround capabilities of organic resources with high fidelity test environments.

This system has also helped with software not developed by our organization. During the early 1980s, the AWACS wing experienced a serious problem with the E-3 navigational computer system. The system consistently failed to capture the turn portion of an established surveillance orbit, potentially causing the E-3 to fly into unauthorized airspace. Serious consequences were narrowly avoided on several occasions. Once notified of the problem, the E-3 AISF was able to reproduce the problem in the laboratory, locate the source in another organization's code, and develop a fix. The modified operational flight program was then tested in the E-3 AISF and delivered to the E-3 fleet in a timely manner.

These types of weapons system test environments are normally established as a part of the weapon system development program at the prime contractor's facility. The test equipment is then either duplicated at or transferred to a government facility for support of the weapon system software after deployment of the weapon system. Since the test environment includes the avionics suite, the cost is very high. In 1995, replacement cost estimates for the AISFs were as follows:

- B-1: $171 million.
- B-52: $54 million.
- Missiles: $51 million.
- E-3: $100 million.

Each AISF is unique and may have more than one hot mockup of the avionics. Simulation computers are typically Harris (now Concurrent) computers and use Fortran, C, or C++, as the source language(s) for the simulation software depending on the specific application. Our experience is that the high cost of these high fidelity test environments is well worth the investment because they enable the software support activity to provide the customer and the warfighter with the required capabilities when they are needed.

## Collaboration

Another key element in fielding capabilities is teamwork between the program manager, system engineer, software developer, warfighter, and tester. The B-52 Mission Planning Software Section is one of our top success stories. This section has responsibility for development and sustainment of the B-52 mission planning software (B-52 Aircraft/Weapons/Electronics [A/W/E]) that runs on the Air Force mission support system (AFMSS). This system essentially automates the process that the flight crews previously performed manually – according to the Technical Orders (TOs), which are used as the basis for the software requirements. One of the most important keys to success is customer involvement. To ensure that the product produced meets the user/customer requirements, the warfighters are involved in each phase throughout the development.

The B-52 A/W/E is one element of the complete mission planning environment, which is a combination of 35 different elements of software and 17 pieces of dedicated B-52 aircraft software, as shown in Figure 1 (see page 6); the Glossary defines the terms in the figure. These are developed by different agencies and contractors, and many serve multiple weapon systems. Integration of all of these applications on a single system to meet overall warfighter requirements is a significant part of our effort.

The main key to success in this area is the in-depth understanding of the entire environment, both hardware and software. The mission planning process is tested from beginning to end, including the production of all flight products. These products are taken through the final verification of actually loading them in our B-52 AISF and flying the missions, complete with weapons, and the recording of all the data for analysis.

Ensuring success begins with customer or user relationships. More than a third of our key people who develop and maintain mission planning applications are on a first-name basis with dozens of stakeholders:

- **B-52 System Program Office**. All mission planning system engineers, program managers, and weapon system integration engineers communicate several times a week.
- **46th Operations Group/Test Squadron**. Responsible Test Organization for mission planning; participates in our development test (DT), DT/operational test (OT), and formal qualification test (FQT).
- **28th Test Squadron**. Final test authority for force development evaluation (FDE).
- **Air Force Operational Test and Evaluation Center (AFOTEC) Detachment 2**. Official OT agency for mission planning.
- **AFOTEC Detachment 5**. Official OT agency for weapon systems like the Cruise Missiles and Joint Air to Surface Stand-off Missile (JASSM).
- **49th Flight Test Squadron**. B-52 Flight Test Squadron at Barksdale AFB.
- **5th Operational Support Squadron**. Warfighters from Minot AFB.
- **2nd Operational Support Squadron**. Warfighters from Barksdale AFB.
- **Mission Planning System Support Facility**. Air Force mission planning software integration, distribution, and support from Hill AFB.

As noted above, throughout the applica-

## Glossary

| | |
|---|---|
| A/W/E | Aircraft/Weapons/Electronics |
| ACM | Advanced Cruise Missile |
| AFMSS | Air Force Mission Support System |
| AFOTEC | Air Force Operational Test and Evaluation Center |
| AFPD | Air Force Policy Directive |
| AGM | Air-to-Ground Missile |
| AISF | Avionics Integrated Support Facility |
| ALCM | Air Launched Cruise Missile |
| AMI | Avionics Midlife Improvement |
| AWACS | Airborne Warning and Control System |
| CALCM | Conventional Air Launched Cruise Missile |
| CALCM C/D | Two versions of the CALCM |
| CLOAR | Common Low Observability Auto Router |
| DAFIF | Digital Aeronautical Flight Information File |
| DDLC | Digital Data Loader Cartridge |
| DT | Development Test |
| DTC | Data Transfer Cartridge |
| DTUC | Data Transfer Unit Cartridge |
| FDE | Force Development Evaluation |
| FPM | Flight Performance Model |
| FQT | Formal Qualification Test |
| ICD | Interface Control Document |
| ICSMS | Integrated Conventional Stores Management System |
| IDD | Interface Definition Document |
| INTEL | Intelligence Data |
| JASSM | Joint Air-to-Surface Standoff Missile |
| JDAM | Joint Direct Attack Munitions |
| JSOW | Joint Standoff Weapon |
| JTA | Joint Test Assembly |
| OAS | Offensive Avionics System |
| OT | Operational Test |
| PFPS | Personal Flight Planning System |
| SRAM | Short Range Attack Missile |
| SEPG | Software Engineering Process Group |
| SMXG | Software Maintenance Group |
| SWPS | Strategic War Planning System |
| TO | Technical Order |
| TBMCS | Theater Battle Management Core System |
| U2A | U.S. Strategic Command to AFMSS |
| WCMD | Wind Corrected Munitions Dispenser |

tion's life cycle the stakeholders meet frequently via face-to-face meetings and teleconferences. At least once a year, a mission planning open house is conducted at the user's base of operations. This includes several days for familiarization with our existing applications and user interface working group meetings to discuss upcoming designs, priorities, trade-offs, and requirements. Our engineers and computer scientists also hit the road, spending an average of more than 200 man-days per year in the field, meeting with the users, other developers, and other program offices to continually coordinate efforts, schedules, and requirements, and to provide familiarization with our systems.

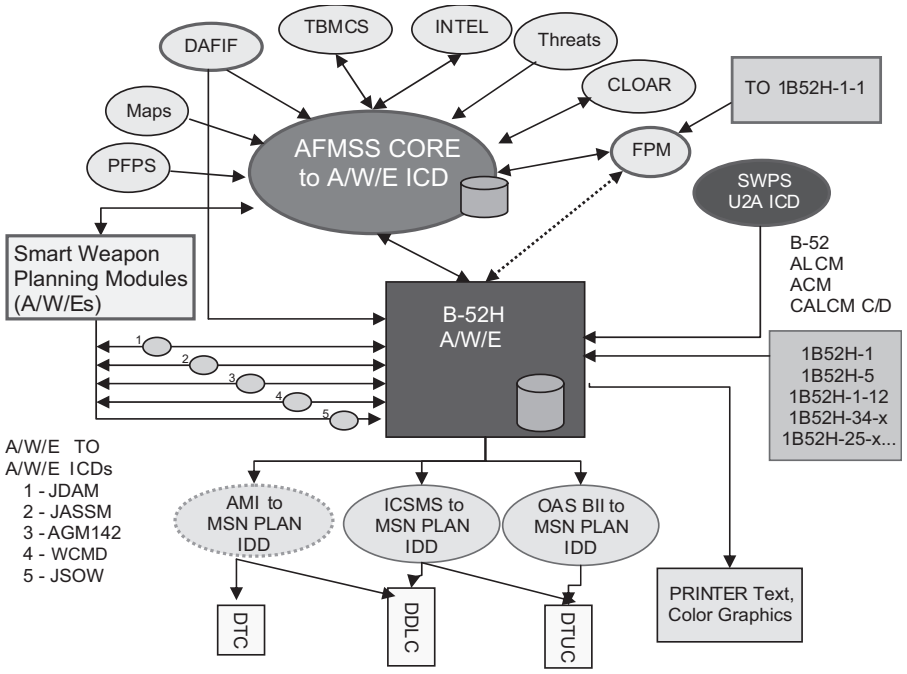
Requirements review boards for our A/W/E applications and AFMSS core are conducted and defect review boards are held following each formal test. Eight official test events were hosted last year. Each event had one or more users or customers working side-by-side with the developers. As part of the development effort, several DTs are hosted prior to the FQT. At least one of these DT tests will be a combined DT/OT that is a development test using operational procedures, data, and crew members, making it as real-world as possible. This process is a profound strength in the organization. Feedback is received from the users continually throughout the development phase.

The OT certification brief is prepared and presented. Using Air Force Manual 63-119, Certification of System Readiness for Dedicated Operational Test and Evaluation, a matrix of 33 certification templates is evaluated that identifies specific problem or risk areas that could hinder the smooth transition from development, through test, to the fielding of a product. All of the communities listed above participate in this process, and the entire group agrees that the product is ready to be tested. This final step provides complete confidence that the products will meet the warfighter's expectations the first time, every time. When a product approaches fielding certification, the actual users have seen it, used it, evaluated it, tested it, and stand behind it along with the developers.

A recent success story centers around a flight performance change to the way mission planners need to account for drag on the B-52 because of external weapons hanging on the wings. The multiple weapon configurations create different fuel burn rates affecting the range of the aircraft. Implementing this change in the TO spanned three software releases and required participation from almost every organization listed above.

Through requirements review, software development, integration, test, and the

Figure 1: *B-52 Mission Planning Environment*



defect review board process, each spiral would further refine the requirements, each time giving the user increased capabilities and enhancing the system effectiveness to plan aircraft missions. It became clear early when dealing with this issue that each member of the team had a different piece of the puzzle. Only through continuous communication and collaboration were the answers to all the questions understood enough to produce a quality tool for the warfighter.

From start to finish, nothing is done in a vacuum without the user. A lot of companies will offer the user an early look or attendance at design reviews, but the customer seldom gets the complete picture or real hands-on experience during development of its system. As explained here, Tinker AFB's B-52 mission planning section goes above and beyond to get the user involved in every step. Nothing is hidden or kept from the customer. By involving the users in requirements reviews, early DT events, and using our integrated suite of test facilities, the customer is allowed to actually run the system end-to-end in one location. A demonstration of one or two isolated pieces of the puzzle is not needed because the user sees the whole enterprise and walks away with a feeling of confidence that what is paid for will provide the capabilities required in the field.

This type of team effort is becoming more important with the Air Force Policy Directive (AFPD) 63-1 cited commander's intent that states, "The primary mission of our acquisition system is to rapidly deliver to the warfighter affordable, sustainable capability that meets their expectations." The objective of AFPD 63-1 is to "create a context that allows the program manager to shape and execute a program with an emphasis on teamwork, trust, common sense, and agility." It further states that "the warfighters, developers/acquirers, technologists, testers, budgeters, sustainers, and industry must plan and execute together in order to meet the Commander's intent." These seem to be lofty ideals, but we have proven they can be done.

## Summary

Fielding capabilities can be enhanced by having high fidelity test environments and by collaboration between all of the participants on a program. The Air Logistics Centers at Robins AFB and Hill AFB have similar capabilities to those that are described in this article, although for different weapon systems. Program managers may be able to take advantage of existing organic resources to reduce cost and risk. Further, partnering agreements can be established between organic software support activities and contractors to facilitate utilization of organic resources in teaming arrangements to work jointly on Department of Defense projects. All three Air Logistic Center software support activities have Web sites (see page 30) that provide contacts.◆

## About the Authors

**John D. Holcomb** is the Operational Flight Programs technical expert in the 76th Software Maintenance Group at the Oklahoma City-Air Logistics Center, Tinker Air Force Base, Okla. He has 40 years of federal service, including 33 years of experience in weapon systems software, and participated in the development of the Department of Defense Standard 2167. He has a bachelor's degree in math and physics (double major) from the University of Central Oklahoma.

**76th SMXG**
**4750 Staff DR**
**Tinker AFB, OK 73145-3318**
**Phone: (405) 736-3835**
**Fax: (405) 736-3584**
**E-mail: john.holcomb@tinker.af.mil**

**Michael Hoehn** currently manages the B-52 Mission Planning Software Section in the 76th Software Maintenance Group at Tinker Air Force Base, Okla. He has more than 15 years experience in both Test Program Set and Operational Flight Program software development and maintenance.

**76th SMXG**
**8080 Perimeter RD STE 107**
**Tinker AFB, OK 73145**
**Phone: (405) 736-5539**
**Fax: (405) 736-4129**
**E-mail: michael.hoehn@tinker.af.mil**

## Coming Events

**September 12-16**
*Practical Software Quality and Testing Conference 2005 North*
Minneapolis, MN
www.psqtconference.com/2005north

**September 18-23**
*International Function Point Users Group 1st Annual International Software Measurement and Analysis Conference*
New Orleans, LA
www.ifpug.org/conferences/annual.htm

**September 19-22**
*Better Software Conference and Expo 2005*
San Francisco, CA
www.sqe.com/bettersoftwareconf

**September 26-27**
*PDF Conference and Expo*
Washington, DC
www.pdfconference.com

**October 16-20**
*Object-Oriented Programming, Systems, Languages, and Applications Conference*
San Diego, CA
www.oopsla.org/2005/ShowPage.do?id=Home

**October 17-20**
*MILCOM 2005*
*Military Communication Conference*
Atlantic City, NJ
www.milcom.org/2005

**October 17-21**
*Quality Assurance Institute's 26th Annual Software Testing Conference*
Orlando, FL
www.qaiusa.com

**May 1-4, 2006**
*2006 Systems and Software Technology Conference*
Salt Lake City, UT
www.stc-online.org